

## ENVIRONMENTAL RADIATION LEVELS IN CENTRAL FLORIDA'S PHOSPHATE MINING DISTRICT

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*Environmental levels of radionuclides and gamma radiation were measured in two communities located near active phosphate mining areas in Florida. Activated carbon canisters and alpha track detectors were used to measure indoor air levels of radon in approximately 100 private homes. Elevated levels of radon ( $> 4$  picocuries per liter [pCi/L]) were detected in 8 of 27 homes in a community built on reclaimed land that had been previously mined. In a nearby community built on unmined land, elevated levels of radon were detected in 1 of 69 homes. All of the homes with elevated levels of radon were built on concrete slabs. Outdoor gamma radiation levels were significantly greater in the reclaimed area than in the unmined area. Air particulates collected from outdoor ambient air at three locations did not contain elevated levels of radionuclides.*

### INTRODUCTION

Large quantities of phosphate deposits are located in the "land-pebble district" of central Florida. Surface mining of these deposits produces 75% of the nation's phosphate production (USNWR, 1995). In many areas, previously mined land has been reclaimed for recreational, residential, and other uses.

Naturally occurring uranium and its decay products are associated with these phosphate deposits. One of the decay products of the uranium-238 decay series is the radioactive gas, radon. Radon can diffuse upwards through the soil and enter homes and other structures built over the deposits. When radon decays it forms daughter products that readily attach to air-borne particulates. These particulates can then be inhaled and deposited in the lungs. When the radon daughters decay, they emit alpha particles that irradiate lung tissue. Thus, long-term exposure to elevated levels of radon can increase a person's risk of lung cancer (Pershagen et al., 1994).

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2. Abbreviations: ATSDR, Agency for Toxic Substances and Disease Registry; fCi/m<sup>3</sup>, femtocuries per cubic meter; pCi/L, picocuries per liter; PCPHU, Polk County Public Health Unit;  $\mu$ R/hr, microRoentgens/hour; USEPA, U.S. Environmental Protection Agency.

3. Key words: Florida, phosphate mining, radon.



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## ESTIMATES OF THE OCCUPATIONAL RADIOLOGICAL HAZARD IN THE PHOSPHATE FERTILISERS INDUSTRY IN POLAND

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**Abstract**—The radiological hazard for workers in the phosphate fertilisers industry was assessed based on measurements in five phosphate plants in Poland. Measurement of absorbed dose rates in air, gamma doses, radon gas concentrations in air, and concentrations of natural radionuclides ( $^{238}\text{U}$ ,  $^{226}\text{Ra}$ ,  $^{210}\text{Po}$ ,  $^{232}\text{Th}$ , and  $^{40}\text{K}$ ) in samples of raw phosphate rocks, products and by-products were performed using an ionisation chamber, thermoluminescent detectors, solid state nuclear track detectors,  $\alpha$  and  $\gamma$  spectrometry, respectively. Using models for dose estimates, individual occupational doses were evaluated for phosphate industry workers involved in the production of fertilisers. On average, the estimated dose for yearly exposure ranged from 2.8 to 5.6 mSv, with the biggest contribution typically coming from phosphate dust. This is a significant amount when compared with the value of the annual dose limit of 1 mSv for the public, but still well below the occupational dose limit of 50 mSv per year.

### INTRODUCTION

Phosphate rocks of sedimentary origin are the main source of phosphorus for man-made fertilisers. The majority of phosphate rocks of sedimentary origin show elevated concentrations of uranium ( $^{238}\text{U}$ ) and its decay products, typically of the order of 1500 Bq. kg $^{-1}$ (1). During the processing of phosphate rocks people are in direct contact with large amounts (up to several ten-thousand tons) of materials containing elevated concentrations of natural radionuclides, which may lead to a hazardous radiation situation.

The radiological impact of phosphate fertiliser production was a subject of numerous studies in the late 1970s and early 1980s(2-4). However, those studies emphasised only external gamma exposure and limited information is available on the total occupational exposure attributable to processing of rock phosphates(1). In contrast, this paper discusses total occupational doses to employees of phosphate fertiliser plants, arising both from external and internal irradiation.

Data are presented for the four largest Polish wet-process plants in Police, Tarnobrzeg, Gdańsk and Poznań, producing over 75% of the nation's phosphate and multicomponent fertilisers which utilise sedimentary phosphate rocks. Included are measurements of the external gamma radiation field and the radon gas concentrations. Additional measurements were made in the phosphate grinding facility and in the plant producing

animal feed supplement using apatites (phosphate rocks of volcanic origin, containing natural radionuclides in concentrations similar to that of typical soils). Samples of phosphate rocks, fertilisers, by-product phosphogypsum and waste waters were collected and analysed. Individual occupational doses were assessed for the workers of various phosphate and multicomponent fertiliser plants.

### POLISH PHOSPHATE INDUSTRY

Since the late 1980s, Poland, like many European countries, has imported most of the phosphate rocks from Northern Africa (Morocco, Tunisia, Algeria), the United States, and the Middle East, in quantities of about  $3 \times 10^6$  tons per year(5). Phosphate rocks are transported to Poland by sea and unloaded in two harbours: Szczecin-Świnoujście and Gdańsk. After that they are transferred to nine chemical plants. Eight out of the nine plants use a wet method of phosphate processing. The annual production of phosphate and multicomponent fertilisers in Poland exceeded  $4 \times 10^6$  tons in 1989 and is summarised in Table 1. The major by-product in the phosphate industry is phosphogypsum produced in large quantities (about  $3 \times 10^6$  tons per year for Polish industry) in wet process phosphoric acid plants. Phosphogypsum containing high levels of  $^{226}\text{Ra}$  separated from  $^{238}\text{U}$  during the production process was never utilised in Poland, as was done in other countries(6,7), where phosphogypsum was used as a building material. In Poland phosphogypsum is at present stockpiled in the vicinity of phosphate plants in amounts of 2.5 to 2.8 million tons annually. Some attempts at safe reprocessing are being made(8).

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Table 15.3.4 shows averaged dosimetric modifying factors given in the NAS/NRC Panel's report.

**Table 15.3.4 Dosimetric Modifying Factors for Converting Radon Risk Estimates for Miners to Members in the General Population** (After National Academy of Sciences/National Research Council, 1991)

Subject Category	Modifying Factor <sup>a</sup>
Infant, age 1 mo	0.69
Child, age 1 year	0.94
Child, age 5-10 yr	0.78
Female (adult)	0.67
Male (adult)	0.71
Average lifetime	0.71

<sup>a</sup> Averaged for secretory and basal target cells.

It is clear that smoking status plays a key role in attempting to estimate an individual's risk from radon exposure. The principal cause of lung cancer in the U.S. is cigarette smoking. Annual lung cancer mortality rates in the U.S. track very well with U.S. cigarette consumption. Of the estimated 143,000 lung cancer deaths expected in 1991, 83%, or about 120,000, can be attributed to cigarette smoking (85% among men and 75% among women). (American Cancer Society, 1991)

If one assumes a per capita radon progeny exposure rate of 0.2 WLM/y for a U.S. population of 250 million and the reduced BEIR IV risk coefficient, an estimated 12,000 lung cancer deaths in 1991 can be attributed to radon exposure. However, 10,000 of these cases would occur in smokers and only about 2,000 in nonsmokers, including those at risk from "environmental tobacco smoke" in the home. The vast majority of these radon-attributable lung cancers are associated with radon progeny exposures below the U.S. Environmental Protection Agency's indoor radon guide of 4 pCi/L.

The UNSCEAR review generally supports risk estimates and the relative risk model reported in BEIR V. The report suggests that a less than multiplicative risk model may underestimate risk to nonsmokers and overestimate risk to smokers; also, that confounding carcinogens found in underground mine environments, such as asbestos, require further evaluation. Two notable conclusions reported are (i) "... little direct evidence on the risks of lung cancer resulting from residential exposure to radon," (geographical studies being difficult to interpret, rendering) "... them unsuitable for use in risk estimation;" and (ii) "... no consistent evidence that radon causes cancer in tissues other than lung."